

**MCGINN & GIBB, PLLC**  
**A PROFESSIONAL LIMITED LIABILITY COMPANY**  
**PATENTS, TRADEMARKS, COPYRIGHTS, AND INTELLECTUAL PROPERTY LAW**  
**8321 OLD COURTHOUSE ROAD, SUITE 200**  
**VIENNA, VIRGINIA 22182-3817**  
**TELEPHONE (703) 761-4100**  
**FACSIMILE (703) 761-2375**

**APPLICATION  
FOR  
UNITED STATES  
LETTERS PATENT**

APPLICANT: Shuichi Karino  
Shuji Ishii

FOR: ROUTE UPDATING METHOD FOR  
MICROMOBILITY NETWORK

DOCKET NO.: ND-395 US

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## ROUTE UPDATING METHOD FOR MICROMOBILITY NETWORK

## BACKGROUND OF THE INVENTION

## Field of the Invention

5           The present invention relates to a micromobility network wherein routers are connected in a tree connection and radio base stations are connected to the routers in the lowest layer such that an updating notification of a route from a mobile terminal is repeated in order from a radio base station to successive higher order routers to update the route and a packet is distributed along the updated route, and more particularly to a route updating method for the micromobility network.

### Description of the Related Art

A conventional mobile support network which is an object  
15 of improvement of the present invention is defined in a draft  
of standards of the Cellular IP (A. G. Valko, "Cellular IP-A  
New Approach to Internet Host Mobility", *ACM Computer  
Communication Review*, January 1999) or the like.

A mobile support network to which the technique described  
is applied shown in FIG. 1. Referring to FIG. 1, in the mobile  
support network shown, fixed nodes are connected in a tree  
connection by transmission devices not shown. Radio base  
stations are connected to those of the nodes which are on the  
bottom side of the tree and communicate with mobile stations  
by radio transmission.

The root node of the tree is connected to an external

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network. All packets of mobile terminals to be interchanged with the external network are distributed through the root node. While a mobile terminal remains connected to a radio base station of the mobile support network, to whichever radio base station the mobile terminal is connected, the transportability from  
5 the external network is assured with the same address.

A route to a mobile terminal is held separately by separate routers. Each time a mobile terminal moves, it transmits a route updating notification. The route updating notification is successively repeated from the ratio base station of the  
10 lowest layer to which the mobile terminal is connected to the router of the highest layer through the intervening routers, and such movement of the mobile terminal is coped with by updating the route on the routers through which the updating notification  
15 passes.

Further, in order to raise the failure resisting property or the expandability of the network, route information is realized by the soft state. In particular, if a time determined in advance elapses after a route is produced, then the route  
20 disappears automatically. The mobile terminal subjectively holds its route. In particular, even when the mobile station stays at one place, the mobile terminal intermittently transmits a route updating notification in order to hold the route.

Distribution of a packet from the external network to  
25 a mobile terminal is performed in the following manner by a router. If a packet arrives at a router from a higher order

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network interface, then a route information search section searches for route information from the destination of the packet to determine an output destination network interface for the packet and signals the packet from the determined interface.

- 5 If a transfer destination cannot be determined even if the route information is searched from the destination of the packet, then the packet is abandoned.

10 This procedure is repeated by each router, and the packet passes a radio base station from a router of the lowermost layer and arrives at the mobile terminal.

15 A packet transmitted from a mobile terminal is processed in the following manner by a router. When the packet from a lower order network interface arrives, the route information search section searches for route information from a transmission source of the packet. As a result, if route information corresponding to the transmission source of the packet is found, then the route information is updated in accordance with a method described below and the packet is signaled from the higher order network interface. If the search  
20 for route information from the transmission source of the packet results in failure, then the packet is abandoned.

25 If the packet arriving from the lower order network interface is a route updating notification packet, then the route is updated in accordance with information included in the updating notification. On the other hand, if the packet is any other packet, then the disappearance time of the route

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information corresponding to the origination source of the packet is extended.

5 The procedure described above is repeated until the packet transmitted from the mobile terminal arrives at the highest layer of the network. When the packet is a route updating notification, it is abandoned in the highest layer of the network. If the packet is any other packet, then it is distributed to the external network. Updating of the route when the mobile terminal moves is performed in the following manner.

10 From the radio base station, a beacon signal for notification of position information, the identification number of the base station and so forth is transmitted intermittently. The mobile terminal receives the beacon signal from the radio base station and detects its movement when the radio base station  
15 connected thereto changes.

If the radio base station connected to the mobile terminal changes, then the mobile terminal transmits a packet of a route updating notification every time. The route updating notification is distributed in accordance with the method  
20 described above, and the route to the mobile terminal is updated or produced.

The route information in each router disappears automatically when a time designated in advance elapses after the route information is updated. While the mobile terminal  
25 continues to transmit data, the route information is successively updated as a result of passage of the data. If

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such data is not transmitted, then the mobile station transmits a route updating notification at intervals shorter than the disappearance time to assure the transportability to the terminal from the outside.

5 In such a network as described above, however, since a router of a higher layer manages routes of a greater number of terminals, updating notifications from a greater number of terminals arrive thereat. Therefore, the total number of updating notifications from all terminals per unit time is  
10 greater with a router of a higher layer, and accordingly, in a higher layer, updating notifications occupy a greater part of the bandwidth of the network and, on the router, a greater number of resources are spent for processing of the updating notifications.

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#### SUMMARY OF THE INVENTION

It is an object of the present invention to provide a route updating method which reduces, in a mobile support system of packet communication wherein a route to a mobile terminal  
20 is managed as the soft state and route information is updated with a route information updating notification (hereinafter referred to as updating notification) from a mobile terminal to assure the transportability to the mobile terminal, the flow rate of updating notifications, which are circulated in a network,  
25 to improve the scalability.

In order to attain the object described above, according

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to the present invention, a reaching range is introduced into an updating notification such that an updating notification which is to reach a higher layer of a network is circulated in a lower frequency than another updating notification which is to reach only a lower layer of the network. Further, the disappearance time of a route in a router positioned in a higher layer of the network is set to a longer time than that in another router positioned in a lower layer of the network. Consequently, updating of a route is performed in a lower frequency with the router positioned in the higher layer of the network than with the router positioned in the lower layer of the network.

In particular, according to the present invention, there is provided a route updating method for a micromobility network wherein routers are connected in a tree connection and radio base stations are connected to the routers in the lowest layer, and an updating notification of a route from a mobile terminal is repeated in order from a radio base station to successive higher order routers to update the route and a packet is distributed along the updated route, wherein a reaching range of an updating notification from the radio base station toward the higher order routers is set so that the reaching frequency of the updating notification is lower with a higher order router.

More particularly, directly lower order routers to each router are numbered to the numbers 1 to n with reference to the direct lower order router accommodation number n and a route from the radio base station to the router in the highest layer

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represented by a route number composed of the numbers of the  
thus numbered routers is applied to the radio base station,  
and upon updating notification, the route number is referred  
to to determine a stage number  $m$  of a transmission range and  
5 the updating notification is transmitted to a higher order router  
corresponding to the stage number  $m$ .

Alternatively, when the mobile terminal stays in the radio  
base station, where the stage number of higher order routers  
from the radio base station necessary to hold the route for  
10 the mobile terminal is represented by  $m$  and the direct lower  
order router accommodation number of each of the routers is  
represented by  $n$ , the transmission range of a packet is set  
to the router in the higher order  $m+1$ th stage from the radio  
base station once per  $n^m$  times.

15 In either case, a notification of the route number applied  
to the radio base station may be issued from the radio base  
station to the mobile terminal, and the mobile terminal may  
determine the stage number  $m$  of the transmission range and  
transmits the stage number  $m$  together with the updating  
20 notification. Or, the radio base station which receives the  
updating notification from the mobile terminal may determine  
the stage number  $m$  of the transmission range. Further, a route  
holding time of each of the routers may be  $n$  times that of the  
routers which are in the directly lower order to the router.

25 With the route updating method, a route updating  
notification reaches a router of a higher layer of a network

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less frequently. Since a router positioned in a higher layer of the network holds a route for a longer period of time, even if an updating notification reaches the router less frequently, a route to a mobile terminal continues to be held. While a  
5 router positioned in a higher layer of the network need hold routes of a greater number of moving hosts, since the reaching frequency of an updating notification of each moving host is lower with a router of a higher layer of the network, the scalability with regard to the number of moving hosts which  
10 can be accommodated in the network is improved.

The above and other objects, features and advantages of the present invention will become apparent from the following description and the appended claims, taken in conjunction with the accompanying drawings in which like parts or elements are  
15 denoted by like reference symbols.

#### BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a block diagram of a conventional mobile support network;

20 FIG. 2 is a block diagram of a micromobility network to which a route updating method according to the present invention is applied;

FIG. 3 is a block diagram showing a functional configuration of a mobile terminal shown in FIG. 2;

25 FIG. 4 is a block diagram showing a functional configuration of a radio base station shown in FIG. 2; and

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FIG. 5 is a block diagram showing a functional configuration of a router shown in FIG. 2.

DESCRIPTION OF THE PREFERRED EMBODIMENT

5 Referring to FIG. 2, there is shown a micromobility network to which a route updating method according to the present invention is applied. In the network shown, routers R are connected in a tree connection, and an external network is connected to one of the routers which is in the highest layer of the network while a radio base station BS is connected to each of the routers R of the lowest layer. The routers R and the radio base stations BS are connected to each other by transmission devices not shown. A mobile terminal MT transmits and receives data through a radio base station BS. The mobile terminal MT and the radio base station are connected to each other by a transmission device not shown.

Where the directly lower order router accommodation number (lower order network interface number) of each router is represented by  $n$ , the  $n$  directly lower order routers are numbered to the numbers 1 to  $n$ . For example, if it is assumed that the directly lower order router accommodation number  $n$  is equal among all routers and  $n = 3$ , then as seen from FIG. 2, the router in the highest layer is numbered as 1 (in FIG. 2, represented as R1); the three routers in the second layer directly below the router of the first layer are numbered as 1, 2, 3 (in FIG. 2, represented as R1, R2, R3, respectively); the three

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5 routers in the third layer directly below the first (R1) router are numbered as 1, 2, 3 (represented as R1, R2, R3 similarly); also the three routers in the third layer directly below the second (R2) router are numbered as 1, 2, 3 (represented as R1, R2, R3 similarly); also the three routers in the third layer directly below the third (R3) router are numbered as 1, 2, 3 (represented as R1, R2, R3 similarly); and also the other routers are numbered in a similar manner.

10 To each radio base station BS, a route from the radio base station to the router of the highest layer is applied in advance with the numbers of the routers numbered in such a manner as described above in addition to an identification number unique to the radio base station BS. For example, in the case of only two radio base stations shown in FIG. 2, a route number of "3211" wherein the number of the router in the lowest layer is the most significant digit and the number of the router in the highest layer is the least significant digit is applied to the left side radio base station (in FIG. 2, the route number is denoted as BS3211) while another route number of "1311" is applied 15 similarly to the right side radio base station (in FIG. 2, the route number is denoted as BS1311).

25 Accordingly, the mth digit from the most significant digit of a route number applied in this manner is the number applied to the router higher by m stages as counted from the radio base station. When the radio base station connected to a mobile terminal changes over, if the value of the mth digit changes,

then this represents that the router in the mth stage changes.

Here, if the router in the mth stage from below (from the radio base station) changes over but the router or routers in the higher stage or stages do not change over, then a route updating notification must be sent to the m+1th stage. This is because the router in the m+1th stage must change over the interface to be used for outputting.

The mobile terminal MT has such a configuration as shown in FIG. 3. Referring to FIG. 3, an antenna 1 is used for communication with a radio base station BS. The antenna 1 is connected to a radio interface 2 so that all packets which are transmitted and received through the antenna 1 pass through the radio interface 2. A communication function section 3 performs preparation, transmission and reception, and interpretation of communication data. Any function as viewed from the user of the mobile terminal MT is implemented by the communication function section 3. An updating notification transmission management section 4 performs transmission management of an updating notification. A beacon signal reception section 5 performs interpretation of a beacon signal which is transmitted intermittently from each radio base station BS. The mobile terminal MT discriminates the identification number of the radio base station BS connected thereto at present and the route number from the beacon signal from the radio base station BS.

Further, the updating notification transmission

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management section 4 supervises transmission of data and performs a process of transmitting an updating notification if data is not transmitted for a fixed time. Further, the updating notification transmission management section 4  
5 supervises the radio base station identification number obtained from the beacon signal and performs a process of transmitting an updating notification if it receives a beacon signal which includes the number of a different radio base station. A transmission range calculation section (not shown) included  
10 in the updating notification transmission management section 4 calculates a range of transmission of an updating notification based on the route number from the radio base station BS.

The radio base station BS has such a configuration as shown in FIG. 4. Referring to FIG. 4, an antenna 6 is used  
15 for transmission/reception to/from a mobile terminal MT. Upon transmission/reception of a packet in which the antenna 6 is used, data passes through a radio interface 7. Connection to a router R is performed through a wire interface 8. A packet transfer section 9 performs a process of signaling data arriving  
20 at one of the interfaces 7 and 8 to the other interface 8 or 7. A beacon signal transmission section 10 performs a process of intermittently preparing a beacon signal packet and signaling the beacon signal packet from the radio interface 7. At this time, the radio base station BS includes the above-described  
25 route number applied to the radio base station into the beacon signal.

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Each router R has such a configuration as shown in FIG. 5. Referring to FIG. 5, a higher order network interface 11 is used for connection to another router R on the farther side from the radio base station BS. n lower order network interfaces 12 are used for connection to the routers R on the nearer side to the radio base station BS. A packet transfer section 13 signals a packet to a designated one of the interfaces 11 and 12. A route information updating section 14 updates or prepares route information with designated contents. A route information search section 15 searches for route information in accordance with a designated method.

A route information management section 16 stores route information and deletes any entry with regard to which a predetermined time elapses after it is updated. The disappearance time is set longer with a router positioned in a higher layer in the network. For example, the disappearance time is set in accordance with the number of routers which are positioned immediately below the router. In particular, where the number of lower order network interfaces is n, the route holding time of the router is set to n times that of the routers immediately below the router.

Now, operation of the system having the configuration described above is described.

Each mobile terminal MT calculates, by the transmission range calculation section thereof, the transmission range of an updating notification in the following manner based on the

route number included in the beacon signal from a radio base station BS, and signals the updating notification including information of the transmission range.

In particular, when the mobile terminal MT moves to another radio base station, it successively checks the digits of the route numbers applied to the new and old radio base stations to search for the lowest digit at which the value is different between the route numbers, and determines the searched out digit as the transmission range of the updating notification.

For example, if the mobile terminal MT moves from the radio base station (BS3211) to which the route number of "3211" is applied to the radio base station (BS1311) to which the route number of "1311" is applied in FIG. 2, then since "3211" and "1311" are different in value in the digits down to the second digit from the most significant digit, the transmission range of the updating notification is determined as the third stage because the stage number must be  $m+1$  as described above. Accordingly, in this instance, the updating notification is sent up to the router in the third stage from below, but is not sent to a router in any higher stage.

If the values of all of the digits coincide with each other and it is determined that the radio base station has changed over, then this signifies that the changeover has occurred between two radio base stations which are connected to the same router. If the  $m$ th digit is the lowest order digit and the values of the  $m$ th digit are different from each other, then

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the stages up to the  $m+1$ th stage must be the transmission range of the updating notification. If all of the digits are equal, then  $m = 0$ .

On the other hand, if the mobile terminal MT stays, then  
5 an updating notification is successively transmitted in order to hold an existing route. In this instance, in order to make the transmission frequency of updating notifications which reach a higher layer lower than the transmission frequency of updating notifications which reach only a low layer, the  
10 transmission range calculation section of the mobile terminal MT changes the transmission range of an updating notification in the following manner.

When the mobile terminal MT stays in one radio base station BS, where the number of stages of higher routers from the radio  
15 base station necessary to hold the route of the mobile terminal MT is represented by  $m$  and the directly lower order router accommodation number of the router  $R$  is  $n$ , the transmission range of a packet is set to a router of the  $m+1$ th stage higher than the radio base station BS once by  $n^m$  times. If a case wherein  
20  $n$  is 3 and  $m$  is 2 is taken as an example, then the transmission range of an updating notification is varied in a period of once per 9 times in the following manner.

1, 1, 2, 1, 1, 2, 1, 1, 3, 1, 1, 2, 1, 1, 2, 1, 1, 3, ...

Each router  $R$  decrements, upon transfer processing of  
25 an updating notification, the transmission range by 1, and if the resulting value is 0, then the router abandons the packet

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without transferring it.

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5 In the example described above, the number of updating notifications which are circulated in order to hold a route in the  $m$ th network from below is  $1/n$  per terminal when compared with that in the  $m-1$ th network from below. On the other hand, since the number of routers accommodated is  $n$ , the number of terminals to be managed increases to  $n$  times in average in a stage higher by one stage. Accordingly, the number of updating notifications which flow in the network is statistically equal

10 between the  $m$ th stage and the  $m-1$ th stage, and the scalability is obtained without depending upon the performances of the routers.

15 While, in the embodiment described above, calculation of a transmission range is performed by each mobile terminal MT, since the mobile terminal MT may possibly have an operation power or processing capacity insufficient to perform fine control with regard to the transmission range of an updating notification, the calculation may be performed not by the mobile terminal MT but by each radio base station BS. In the following,

20 operation in this instance is described.

25 The mobile terminal MT transmits an updating notification without setting a transmission range. At this time, the identification number of the radio base station BS to which the mobile terminal MT has been connected formerly is included in the updating notification. Further, the interval of an updating notification to be transmitted in order to hold the

route is set with reference to a disappearance time of a route held by the routers R of the lowest layer.

5 The radio base station BS has a route updating information holding section and holds a route information disappearance hour of the router R in the higher layer to the radio base station BS for each mobile terminal MT in the route updating information holding section. If a route updating notification from a mobile terminal MT arrives at the radio base station BS, then the radio base station BS determines a reaching range of the updating  
10 notification in a similar manner as in the procedure described hereinabove in the description of the embodiment and signals information of the reaching range together with the updating notification. Assuming that the updating notification is received immediately after it is signaled, the route information  
15 holding section in the radio base station BS updates the factor of the mobile terminal.

According to this operation, the mobile terminal MT must only transmit an updating notification without being conscious of the transmission range, and the necessity for management  
20 of the disappearance time of a route in the router R of the higher layer or the range of movement is eliminated.

While a preferred embodiment of the present invention has been described using specific terms, such description is for illustrative purposes only, and it is to be understood that  
25 changes and variations may be made without departing from the spirit or scope of the following claims.

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